Preface

It is with great pleasure that we present this book to the public. In principle it is about thermodynamics, especially the simulation of thermofluid systems.

In popular opinion, thermodynamics is considered to be highly abstract and difficult to comprehend with its many symbols. We endeavor to show the reader how simple and beautiful thermodynamics really is.

To achieve this simplicity we apply two innovations:

For us, entropy is a substance-like concept, a kind of thermal charge, analogous to the well-known electric charge, and not the abstract and incomprehensible Clausius integral. This is by no means a new idea: apart from Sadi Carnot himself, people such as Callendar (1911), Job (1971), Falk (1976) and Fuchs (1996) all adopt the same point of view. We stress where thermal charge is analogous with electric charge and also point out the differences between them.

To represent thermal systems we use Bondgraphs (BG), which are admirably suited to this purpose. They allow us to avoid many complex equations with numerous subscripts and superscripts. Of course, literature on BG abounds, including three books by present co-author Prof. Thoma and several other books published by Springer.

We use BG more as a means to clarify the nature of physical variables and their analogies in other fields rather than from the viewpoint of electronic data processing. For example, the difference between c_v (specific heat at constant volume) and c_p (specific heat at constant pressure) is common to all multiport-Cs; and BG make this very clear.

We start chapter 1 with thermodynamics as universal science and with entropy as carrier of thermal power, commonly called heat. The difference between heat and heat flow, or of entropy and entropy flow is stressed, although they are connected by a simple integration over time. We include thermal radiation and convection by moving fluids (and electricity, chap. 1.6). We also state when simulation by entropy flow and simulation with heat flow is appropriate. The Clausius notion of entropy as a complex integral is also given, but it applies only to multiport-Cs.

Chapter 2 deals with the effects of the ever-present frictions (or irreversibilities). This includes the Carnot cycle which was invented in 1824 precisely to eliminate the effects of friction; other proponents of entropy as thermal charge are mentioned above.

In chapter 3 we consider systems with variable mass and variable mass flow. Here we use pseudo-BG with pressure and temperature as efforts, and mass flow and enthalpy flow as flows. This leads to hot gas resistors, heat exchangers and thermofluid machines.

In the following chapter 4, we apply these concepts to chemical reactions and osmosis. In fact BG can explain why some chemical reactions produce cold and not heat (the so-called endothermic reactions). This requires the concept of entropy stripping.

In chapter 5 our viewpoint changes: from considering real apparatus and machines, we descend by 20 orders of magnitude and treat only particles, atoms or degrees of freedom (DOF) of atoms, with the hope that the laws of nature are still the same. We discuss statistical aspects which apply to single DOF and relations to theory of information and its biological relevance. This chapter has been written in collaboration with Prof. Henri Atlan of Paris and Jerusalem. We thank him sincerely for his invaluable contribution. This chapter also gives some applications of entropy and information theory. It is largely based on Prof. Thoma's works during his stays at the International Institute for Applied System Analysis (IIASA) near Vienna, Austria and brings in questions of particular concern today, such as solar energy and global warming.

Appendix 1 gives tables of BG symbols which may help the uninitiated to understand this text; naturally a wide range of background reading or some familiarity with BG would be valuable.

Appendix 2 gives some notions useful for the application of BG in automatic control. There follow some historical remarks with some points that seem important to us.

Apart from the cross-disciplinary ramifications of the ideas in this book, a particular interest of Dr. Mocellin, it originates in essence from Prof. Thoma's experience as fluid power consultant and later as Bondgrapher. This involved traveling to many countries where he also arranged meetings and held discussions with people in the world of science. In Prof. Thoma's experience, nothing beats a face to face meeting for developing new ideas. Formerly we had a language problem with this, but nowadays all scientists are able to communicate in English.

The readership of this book, written more from the point of view of engineers, especially control engineers, than from that of physicists, encompasses everyone, starting with graduate students who are interested in thermodynamics and its simplicity when applied correctly, and who are also intrigued in the common structure of science across disciplines.

As this is not a textbook, there are no exercises for students, although they could be added. Indeed, part of the content has been used by Prof. Thoma for his graduate course at the University of Waterloo, Ontario, Canada, entitled: "Modern Machine Design by Bondgraphs", which included exercices for students.

Understanding the behavior of matter has always been the goal of mankind. We hope that our book makes a contribution towards that goal.

We have had discussions with many people and would like to thank them all. Most important are our wives Rosemarie Thoma and Anne Mocellin-Borgeaud, for whose patience and support during the difficult period in which the book was under construction we are extremely grateful.

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